A STUDY ON THE SYSTEM FOR TREATMENT OF ADHD USING VIRTUAL REALITY

J. M. Lee[1], B. H. Cho[1], J. H. Ku[1], J. S. Kim[1], J. H. Lee[2], I. Y. Kim[1], S. I. Kim[1],
[1]Department of Biomedical Engineering, Hanyang University, Korea
[2]Department of Psychology, Choong-Ang University, Korea

Abstract-**Attention Deficit Hyperactivity Disorder (ADHD) is a disorder characterized by a persistent pattern of inattention and/or hyperactivity/impulsivity that occurs in academic, occupational, or social settings. Though the number of men having this disorder increases gradually all over the world, the treatment for ADHD is limited to stimulant medications or a cognitive behavioral treatment. This fact caused us to develop the newly system for treatment of ADHD using Virtual Reality technology. Psychotherapy using VR has some advantages that it is safer and more effective than conventional therapeutic methods. We divided subjects into control group and VR group depending on whether they will have VR therapy with HMD & Tracking system. And we compared the results of CPT (Continuous Performance Test) between before and after the experiments. So we will show the effect of this VR system and the possibility VR technology can contribute greatly to the treatment of ADHD in this paper.**
Keywords - **ADHD, VR, HMD, Tracking**

I. INTRODUCTION

According to DSM-IV (American Psychiatric Association, 1994), Attention Deficit Hyperactivity Disorder (ADHD) is divided into 3 patterns such like inattention, hyperactivity and impulsivity[1]. This is one of behavioral disorders that can be shown generally during a child's growth progress.

These primary problems can cause the emotional maladjustment including an absence of self-confidence as well as the secondary problems, that is, maladjustment to one's social environment like academic settings, the relationship with friends. Especially these land oneself in trouble when a child is under school age that learning becomes structuralized and personal relations widen.

The epidemiological studies about the rate of the outbreak of illness in America revealed prevalence rates generally ranging from 4% to 12% in the general population of 6 to 12 years old[2]. According to the result Korea Institute for Health and Social Affairs investigated how many children have behavioral problems in primary school students of 2,899, 8.6% of them showed symptoms of inattention and impulsivity and other study revealed that 9.5% of subjects showed the same symptoms[3].

One method having been used to treat ADHD is stimulant medications making use of Ritalin, Dexedrin, Cylert.

The other is behavior therapy based on several simple and sensible notions about what leads children to behave in socially appropriate ways. But both two methods have some following disadvantages; side-effects (Ritalin can cause a cancer of liver[4]), needs of much time and efforts from many persons concerned. To overcome these disadvantages, we developed the treatment system using VR technology.

The goal of this experiment is to develop the VR system to treat ADHD and verify the effectiveness of the VR system to treat children having ADHD. In general, VR program is progressed by the measurement of subject's EEG signal. By comparison between the results of Continuous Performance Test (CPT) before and after exposure to VR, we present how effective our VR system is for treatment of ADHD children.

II. DISCRIPTION OF VIRTUAL REALITY SYSTEM

1. The Characteristics of Virtual Reality System

The recent advancement of computer and display technology enables people to make the VR environment that can show a similar situation to real to a subject. Unlike the existing treatment methods, VR Therapy system does not have any side effects and can present many situations to a subject without making efforts of many people. As the supply of personal computer increases and the price of HMD (Head Mounted Display) and Head Tracker decreases gradually, many children having ADHD will be able to be treated in their home soon.

Fig. 1 Virtual Classroom

2. Virtual Reality system

The hardware used for creation of the virtual world was the personal computer system having a Pentium-III 500MHz CPU, 256MB RAM, and a 3D acceleration graphic card. To enhance the immersion to virtual environment, we used HMD and Head Tracker having 3 DOF (Degree of Freedom)[5]. The equipment supporting 4 channels of LAXTHA Co. Ltd was used for acquiring a subject's EEG

Report Documentation Page

Report Date 25 Oct 2001	Report Type N/A	Dates Covered (from... to) -

Title and Subtitle A Study on the System for Treatment of ADHD Using Virtual Reality	Contract Number
	Grant Number
	Program Element Number

Author(s)	Project Number
	Task Number
	Work Unit Number

Performing Organization Name(s) and Address(es) Department of Biomedical Engineering Hanyang University, Korea	Performing Organization Report Number

Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	Sponsor/Monitor's Acronym(s)
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement Approved for public release, distribution unlimited

Supplementary Notes Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom., The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	Classification of this page unclassified

Classification of Abstract unclassified	Limitation of Abstract UU

Number of Pages 4

signal. We used Rhinoceros (Robert McNeel & Assoc.) and 3D StudioMax (Kinetix) as 3D modeling tools. And we built a real time virtual environment with Visual C++ 6.0, DirectX 7.0a SDK (Software Development Kit).

VR program is progressed by the FFT processing of subject's EEG signal. Subjects are measured baseline for 1 minute before session every day. A little change is given to virtual environment whenever subject's Beta(15~18Hz) goes up the threshold value in correspondence with the day-baseline through processing of EEG signal obtained from subject. Subjects can see the counter number on the left which indicates the rate of progress and disappears when it become 100. After a while, a dinosaur egg rises from the desk. Then the egg is broken to two pieces. From the broken egg, one part of a dinosaur picture steps up to whiteboard in order gradually. If all 6 parts are put together, a subject can hear the dinosaur's roaring. After completion, the scripts including the explanations about the dinosaur in the picture are presented. After the explanations, 5 questions about the dinosaur are presented one by one and the subject is encouraged to press the number key that is thought to be a correct answer. The results about biofeedback data and picture completion time are saved automatically into a specified file.
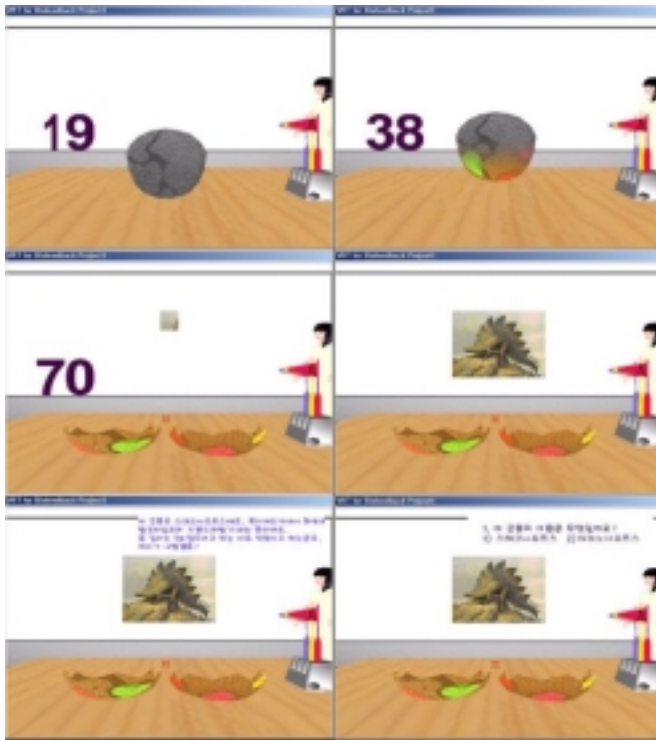

Fig. 2 The images of VR Biofeedback program

III. CLINICAL EXPERIMENTS

1. Subjects

Subjects are young boys staying in a reformatory. They are thought to have impulsivity and attention problem. The adolescents in the delinquent group have a tendency to be more identified as having ADHD than non-group[6]. 10 persons are a control group and 10 persons are a group to experience VR. None had the experience of using an HMD or VR in any sense. Each subject was fully informed of the experimental procedure to understand the study and the fact that he was free to withdraw from the experiment at any time. Subjects are connected to the EEG signal acquisition device using three electrodes attached to their scalp at the placement of Cz and grounded at the right and left ears. The sampling frequency of EEG signal acquisition is 256Hz. The latest 3-second data of acquired EEG signal are analyzed in frequency domain through Fast Fourier Transform. And then we can extract frequency parameter such as Delta (0.5~3Hz), Theta (4~7Hz), Alpha (8~12Hz), SMR (12~15Hz), and Beta (15~18Hz). The data is updated every 0.5 second and we can measure frequency parameter in real time.
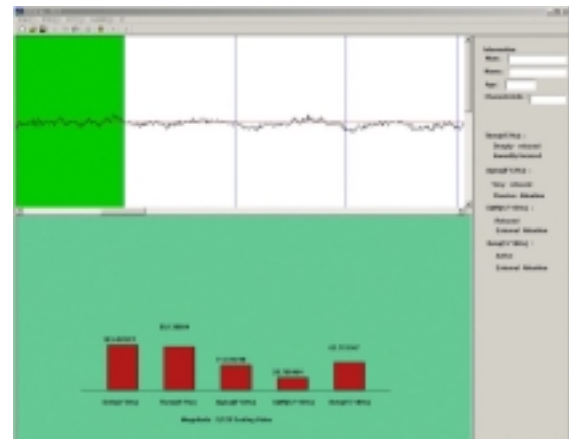

Fig. 3 Biofeedback measurement program

2. Evaluation

Subjects performed total 10 sessions and each session was made to take 10 minutes because usage of VR system within 20 minutes does not cause any significant physical effect on the healthy young subjects[7]. VR group undergoes a CPT (Continuous Performance Test) before and after exposure to VR. On the other hand, Control group waits during VR experiment and only undergoes a CPT at the same time with VR group. CPT is widely known to be effective in discriminating between an ADHD child and a normal child and measuring stimulant medication (Corkum & Siegel, 1993; Coons, Klorman, & Borgstedt, 1987; Fischer, 1996; Garfinkel et al., 1986). To verify the effectiveness of VR, we measured various dependent variables such like Response Time (RT), Standard Deviation of RT, Variability, Errors of Commission, Errors of Omission, Response Sensitivity (d' score), etc.

Errors of Omission are interpreted as a measure of inattention and errors of commission are as a measure of impulsivity or failure to inhabit response and Standard deviation response time is a measure of variability or consistency[8]. Response sensibility is a measure of the decrease of performance with the passage of time.

IV. RESULTS

In this paper, we presented the results obtained by comparing and analyzing the numerical values before and after VR experiments in Table 1. According to those results, VR group showed the considerable changes, compared with those of control group. A little changes of control group are thought to be the results from the experience of 1st CPT.

Decrease of errors of omission or commission says VR group's inattention or impulsivity is more decreased than that of control group. According to Fig. 5, response sensibility after VR treatment was decreased than before VR treatment and control group. This means that the rate to response sensitively and impulsively decreased and subjects who experienced the VR treatment thought more carefully when they were supposed to choice.

		VR Group	Control Group
Response Time	Pre-	54.52 (15.72)	52.77 (17.89)
	Post-	38.62 (19.80)	47.16 (22.88)
Errors of omission	Pre-	13.22 (5.02)	9.22 (5.47)
	Post-	3.67 (2.60)	8.56 (4.45)
Errors of Commission	Pre-	19.44 (7.67)	19.11 (7.77)
	Post-	12.67 (10.33)	15.11 (10.47)
S.D. of RT	Pre-	61.05 (10.54)	52.71 (9.26)
	Post-	60.27 (9.10)	57.31 (12.54)
Variability	Pre-	62.63 (11.39)	51.85 (8.24)
	Post-	56.23 (6.63)	54.52 (11.27)
Response Sensitivity	Pre-	55.35 (8.30)	53.33 (5.52)
	Post-	41.83 (7.70)	50.52 (10.77)

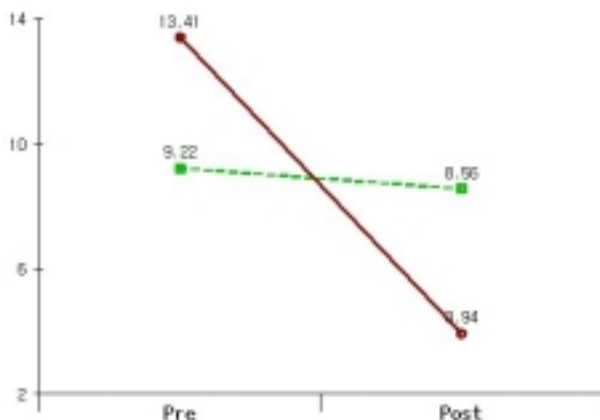Table 1. CPT results based on measurement time
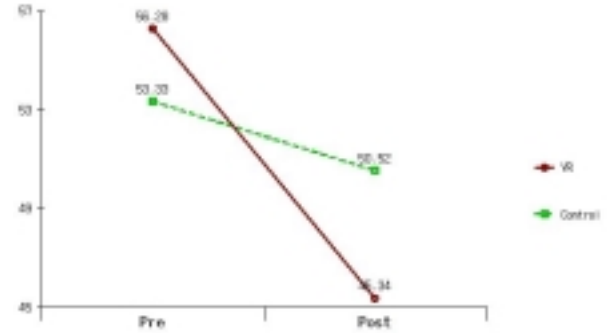

Fig. 4 Errors of Omission

Fig. 5 Response Sensibility

V. CONCLUSION

So far we have presented the results of experiments using VR technology for treatment of ADHD unlike the existing methods. It is premature to say that this VR system is fully usable. In clinical tests, however, we were able to get the fact that the improvement of attention is achieved through VR and the system using VR technology is effective in treating children having ADHD.

VR system's advantages that we could get in this paper are in the following.

1) It is easy to develop various environments to make ADHD children be treated.
2) Less people are required to maintain the treatment than before.
3) It is easy to make steady progress with the treatment, arousing one's interest not to be tired.

But the disadvantage of this experiment is that any authority of medical doctor was not given to subjects. In the future, we will need that. It will be also useful to develop more methods using VR. For example, it is needed to give VR Cognitive Training (CT) to be effective in improving subject's attention and concentration. And it is required to compare and analyze the results between VR system and Non-VR (i.e. without HMD and tracker system). The comparison between CT and Biofeedback Training and the quantitative verification by examining bio-signals are also required. In the last place, we are going to develop stereoscopic display because stereoscopic display for virtual reality has been shown to improve user depth perception and task performance in a variety of tasks[9,10].

REFERENCES

[1] American Psychiatric Association (1994), "Diagnostic and Statistical Manual of Mental Disorders" 4th Edition. Washington D.C.

[2] Ronald T. Brown, Wendy S. Freeman, James M. Perrin, Martin T. Stein, Robert W. Amler, Heidi M. Feldman, Karen Pierce, Mark L. Wolraich, "Prevalence and Assessment of Attention-Deficit/Hyperactivity Disorder in Primary Care Settings", PEDIATRICS Vol. 107 No.3 March 2001

[3] Kim. Ji Hye, "The Correlation Study Between Intelligence and Attention Hyperactivity Disorder Among Gifted Children", A master's thesis, Dept. of Psychology, Graduate School of Sungshin Women's University, 1998

[4] Peter Montague, "ADHD and Children's Environment", Rachel's Environment & Health Weekly #678, December 2, 1999

[5] InterSense Inc. "User Manual for InterTrax2 Versions 1.0 and above" Available at http://www.isense.com

[6] Jung, Hyun-Oak. "Attention Deficit Hyperactivity Disorder in Korean Juvenile Delinquent –As of The Larceny And Violent Criminals In Juvenile Prison-". A master's thesis, Dept. of Psychology, Graduate School of Sungshin Women's University 1998

[7] Takami Yamaguchi, "Physiological Studies of Human Fatigue by a Virtual Reality System", Presence, Vol. 8, No. 1, February 1999, 112-124

[8] Clifford L. Corman, M.D., Lawrence M. Greenberg, M.D., and Ross D. Crosby , Ph.D., "The Assessment of Medication Effects in Attention Deficit Disorder Using the Test of Variables of Attention (T.O.V.A)", CyberPsychology & Behavior Volume 3, Number 3, 2000, Mary Ann Liebert, Inc.

[9] Louis B. Rosenberg. "The Effect of Interocular Distance upon Operator Performance using Stereoscopic Displays to Perform Virtual Depth Tasks". In Proceedings of IEEE Virtual Reality Annual International Symposium 93, 27-32. Sept. 1993.

[10] Colin Ware, Kevin Arthur and Kellogg S. Booth. "Fish Tank Virtual Reality". In proceedings of InterChi '93, pages 37-41. April 1993.